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Dobrich

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(54) **ENHANCED DISPLAY**

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Related U.S. Application Data

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G02F 1/1335 (2006.01)

(52) **U.S. Cl.**
CPC ***G02F 1/133504*** (2013.01); ***G02F 1/133606*** (2013.01); *G02B 2207/123* (2013.01)

(58) **Field of Classification Search**
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USPC 349/95, 104
See application file for complete search history.

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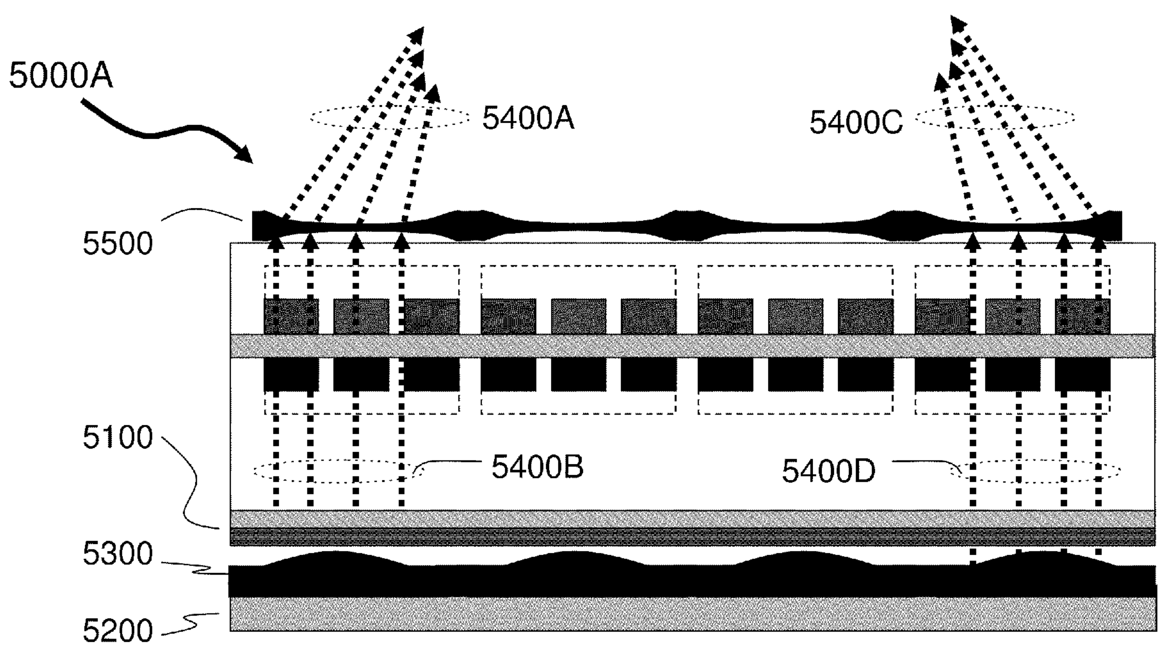
(57) **ABSTRACT**

Security of communications between users involving mobile devices has to date focused to ensuring message integrity, preventing attacks as well as verification/authentication of the user to access the message. At the same time manufacturers of LCD displays for use within electronic devices, particularly mobile devices have focused to extending the viewing angle of these displays, their brightness and contrast. As a result content that has been securely encrypted, delivered, and decrypted is visible to malevolent individuals or organizations around the user when accessing this content. As such secure information, credentials, etc may be divulged without the user being aware. Accordingly the invention acts to limit the external viewing angle of LCD displays allowing reduced breaches of confidential information. Embodiments of the invention can be integrated with the LCD displays during manufacturing, added to the mobile device in assembly or form part of an after-sales option.

15 Claims, 10 Drawing Sheets



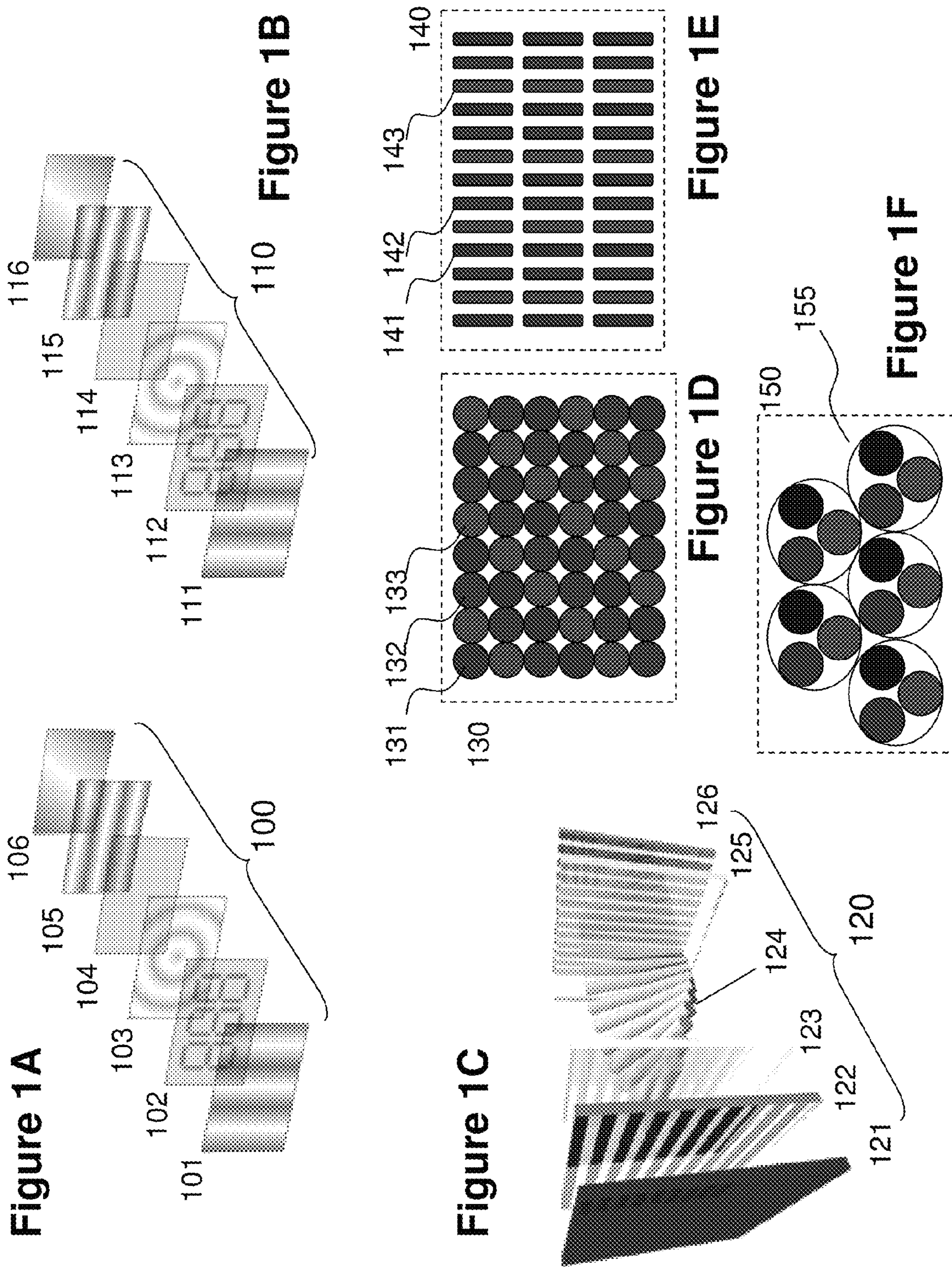


Figure 1A

Figure 1B

Figure 1C

Figure 1D

Figure 1E

Figure 1F

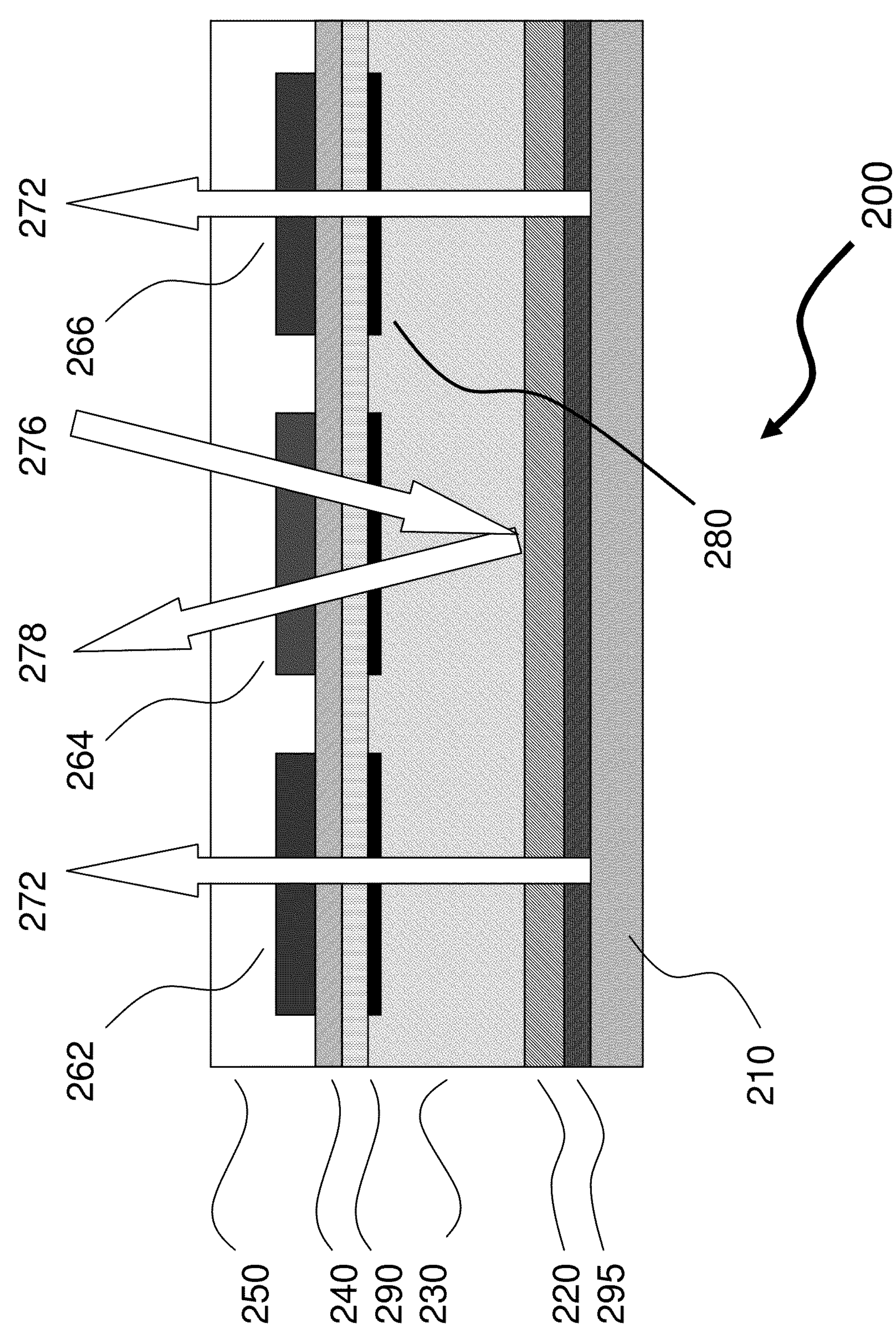


Figure 2

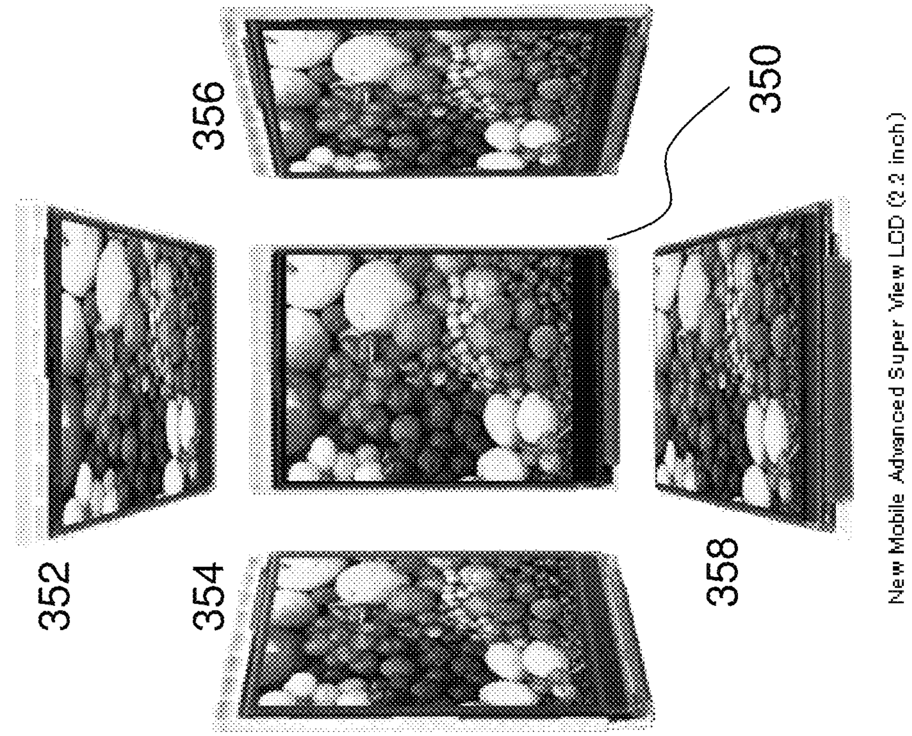


Figure 3B

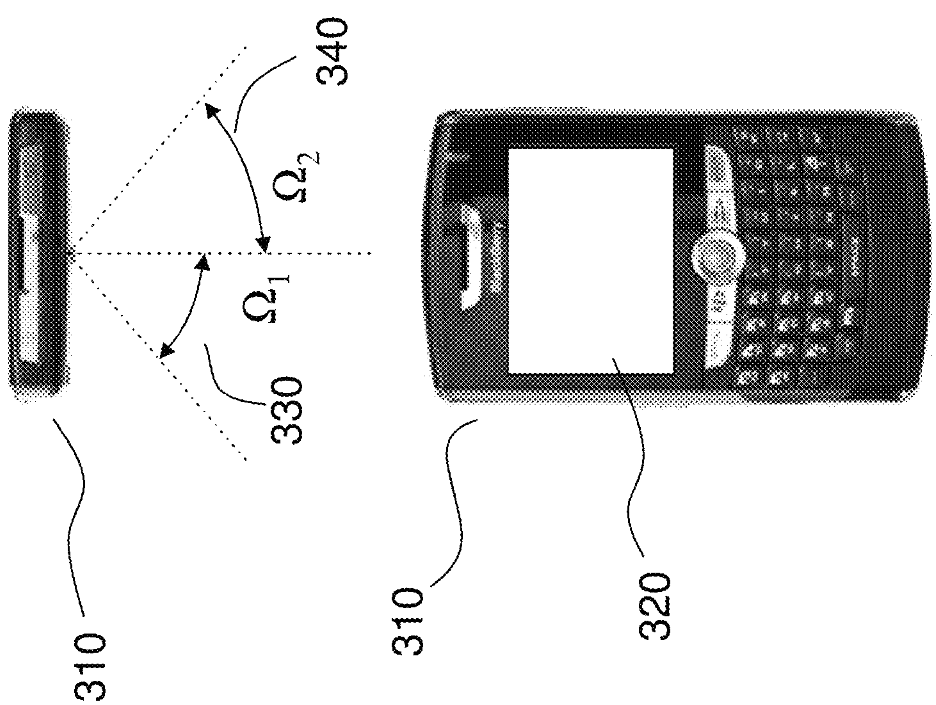


Figure 3A

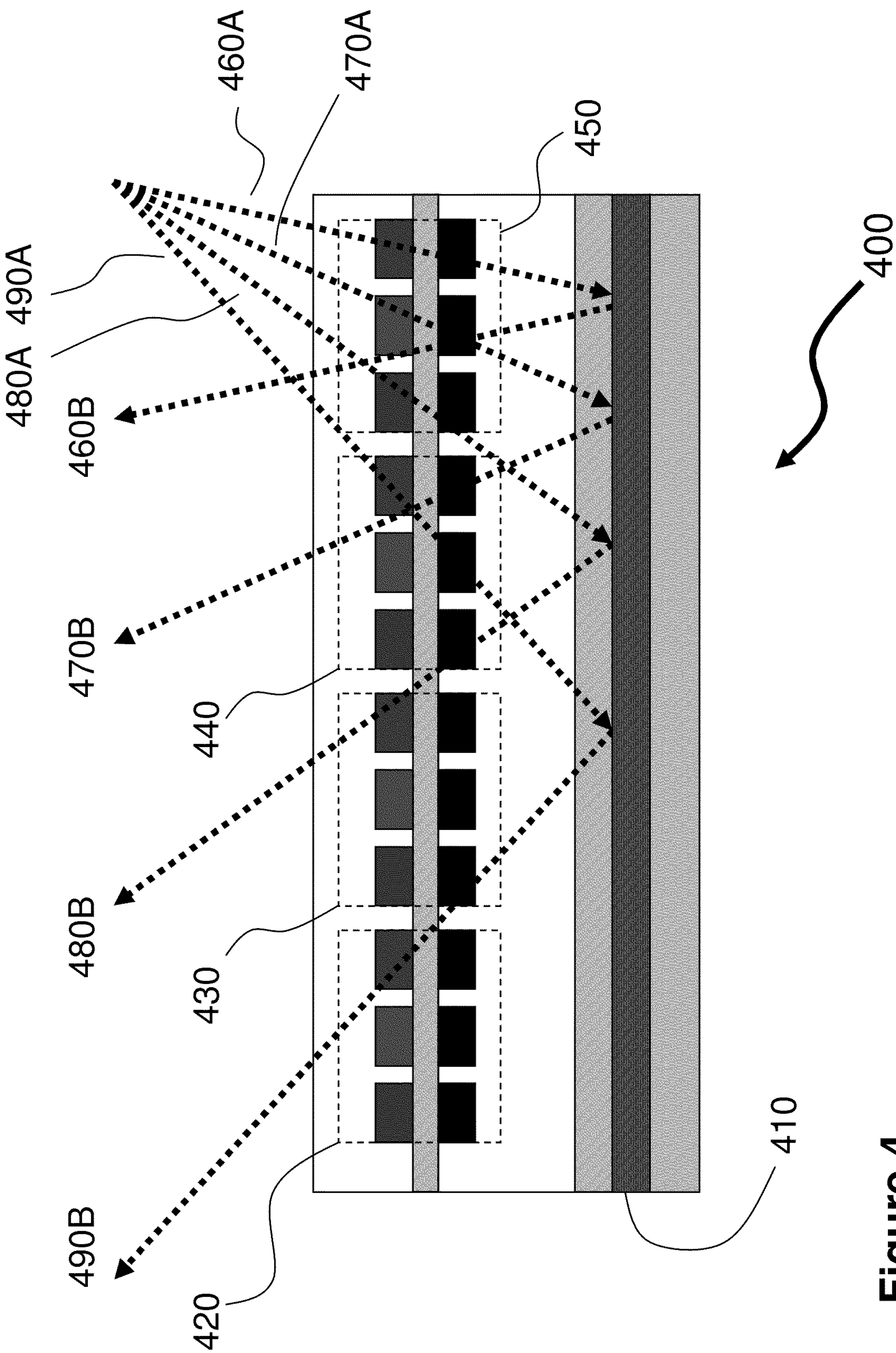

460A
470A
450
400
490A
480A
460B
470B
440
480B
430
490B
420
410

Figure 4

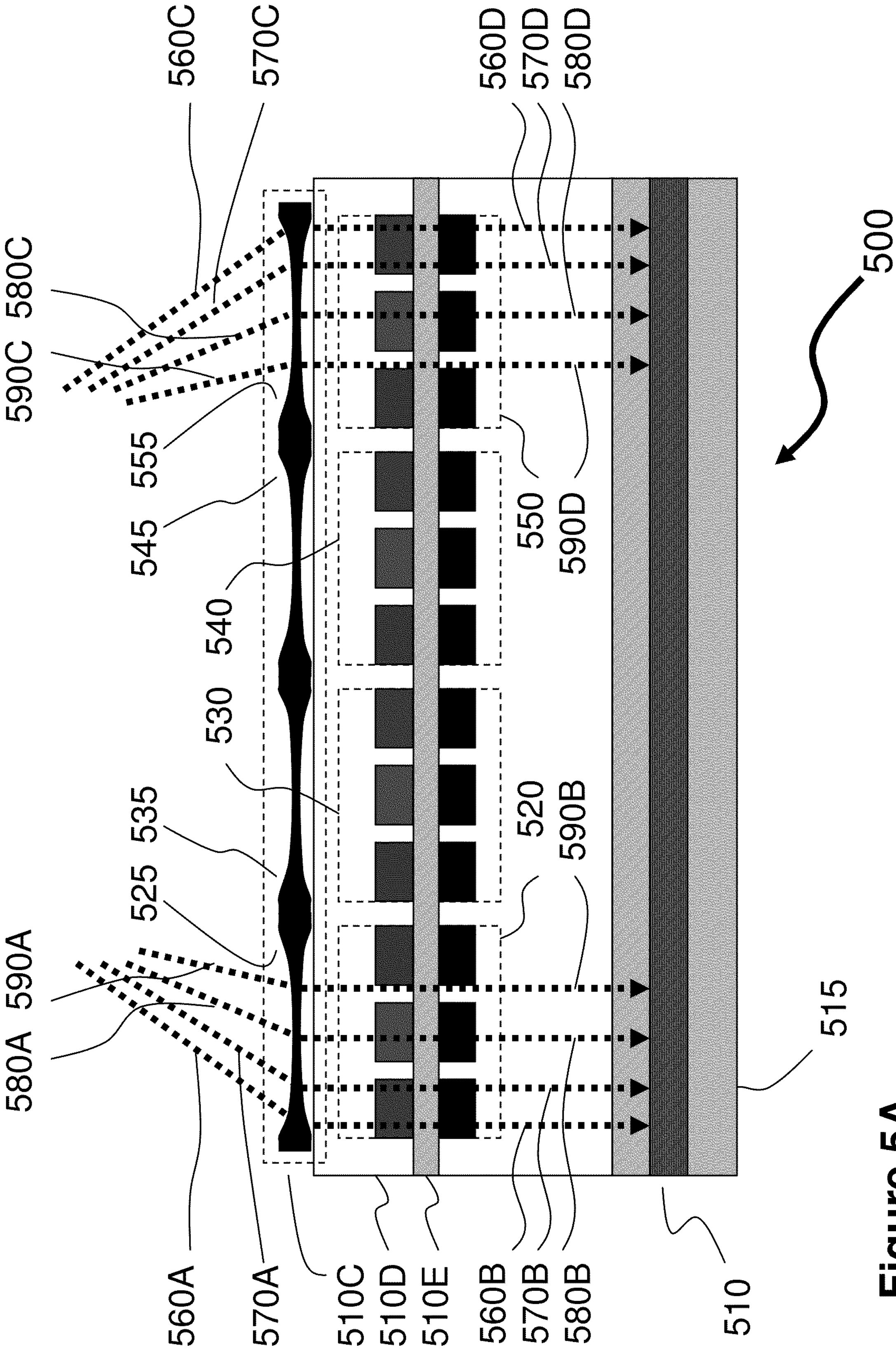

560C
570C
560D
570D
580D
590C
580C
555
545
540
550
590D
530
535
525
520
590B
590A
580A
560A
570A
510C
510D
510E
560B
570B
580B
510
515
500

Figure 5A

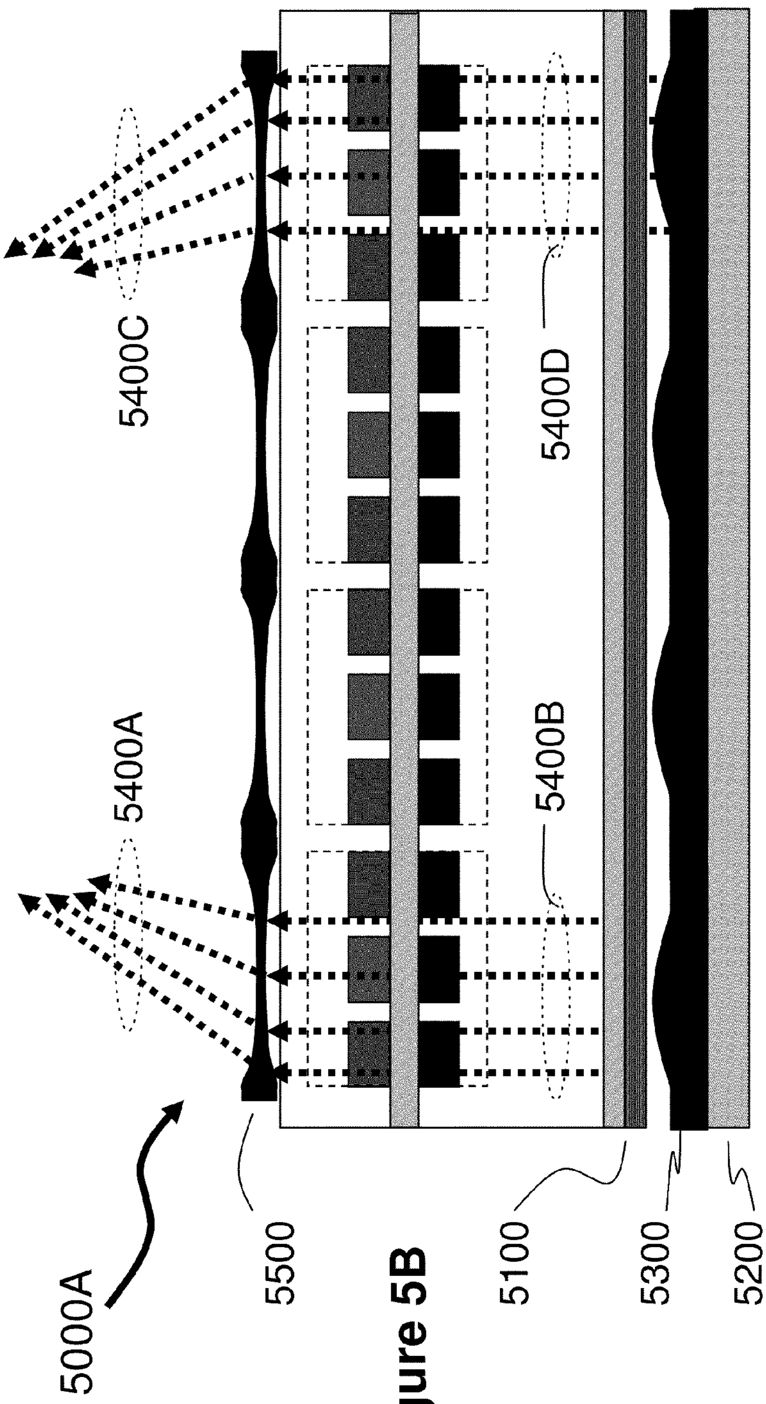


Figure 5B

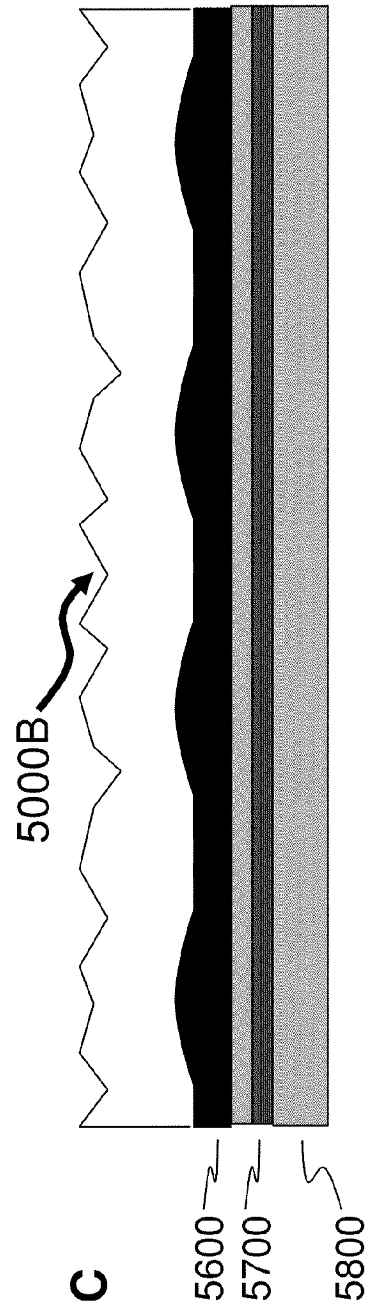


Figure 5C

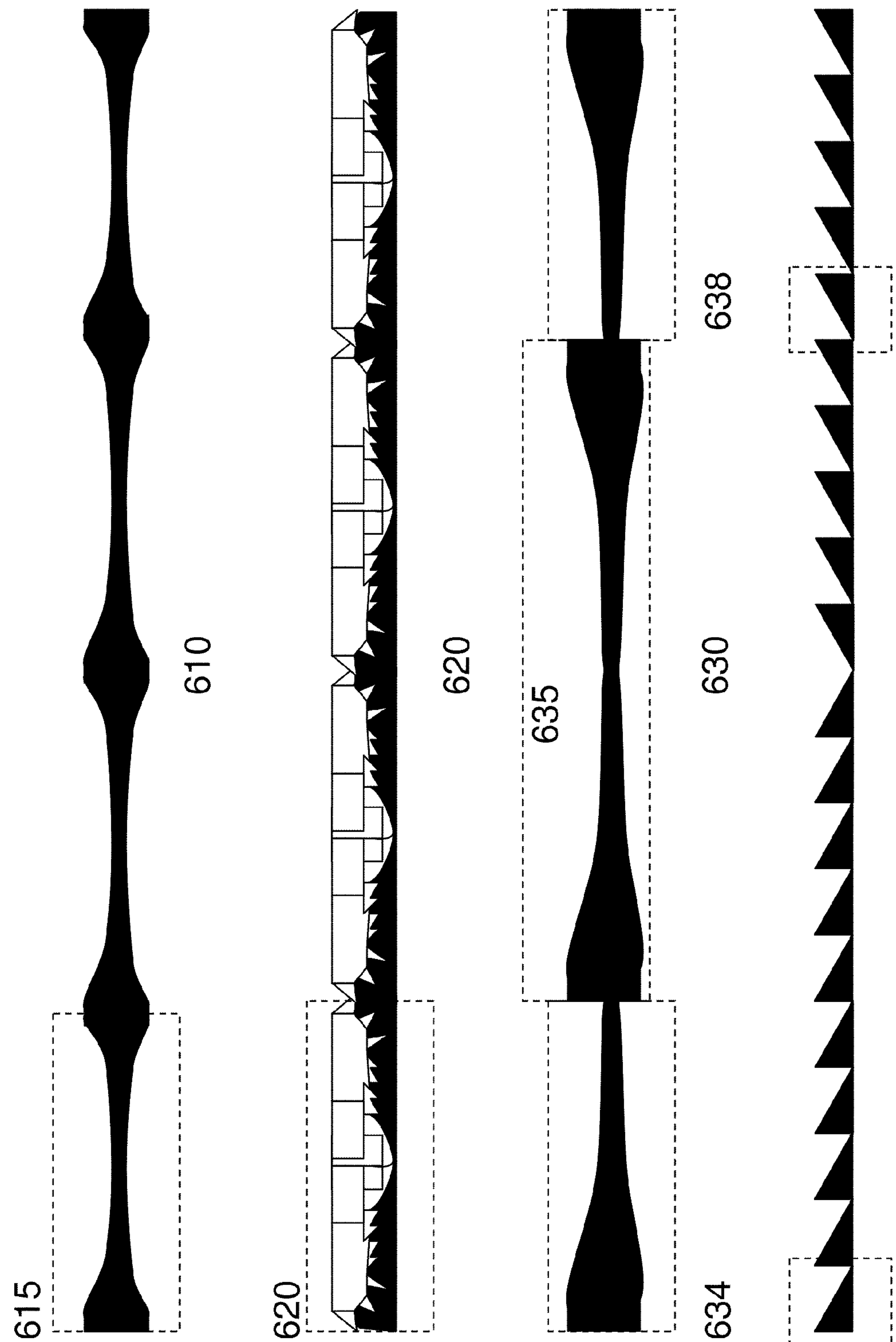


Figure 6

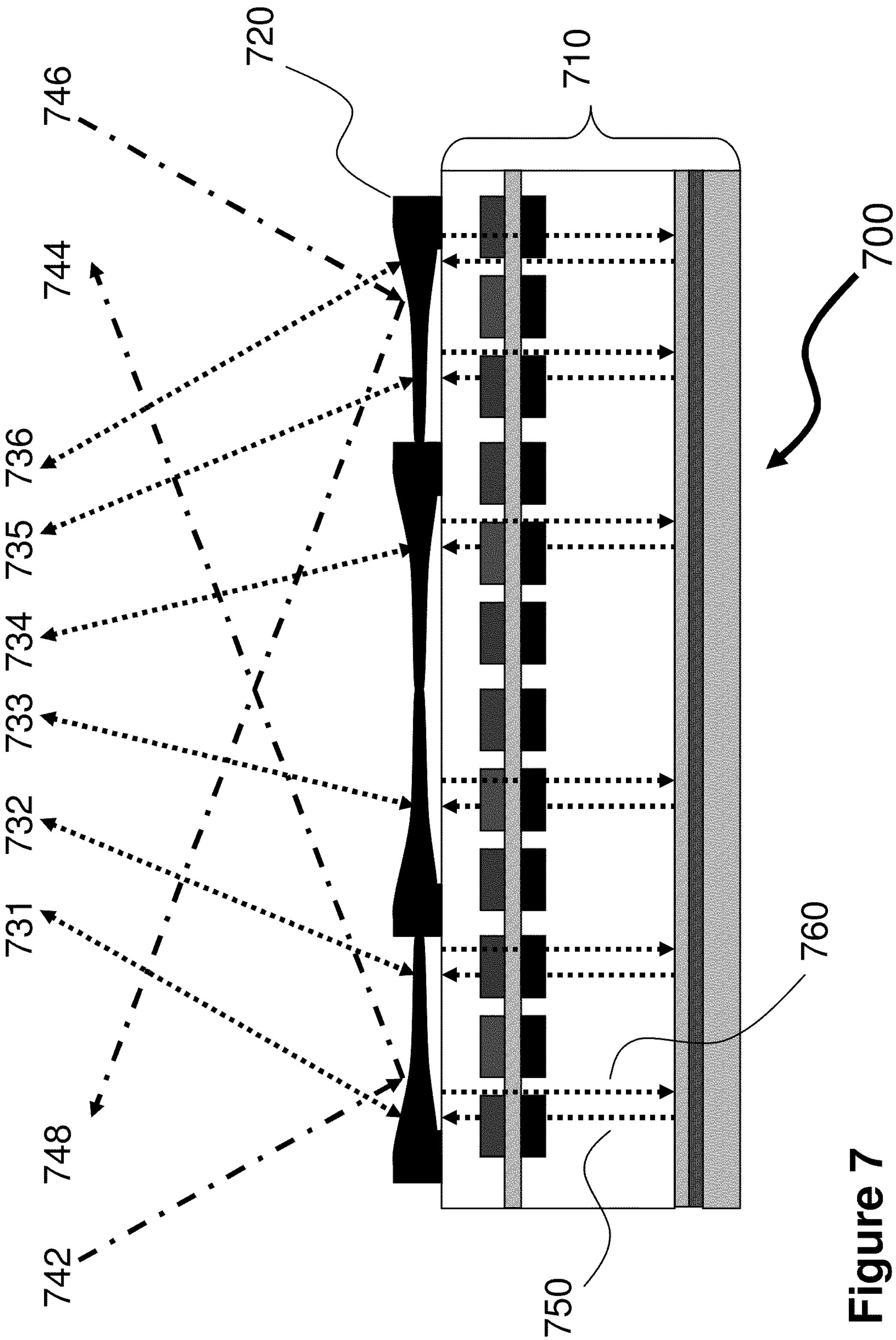


Figure 7

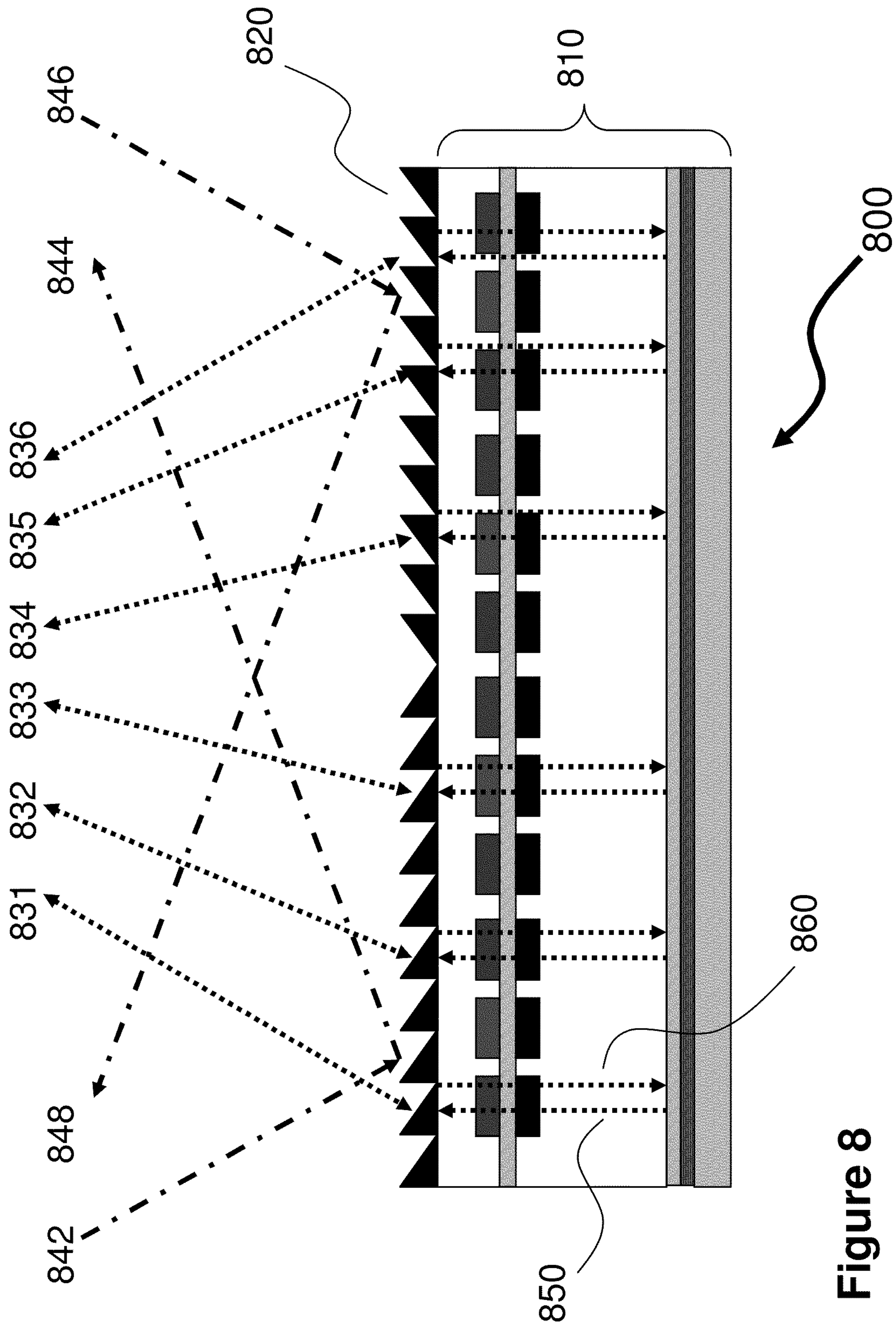


Figure 8

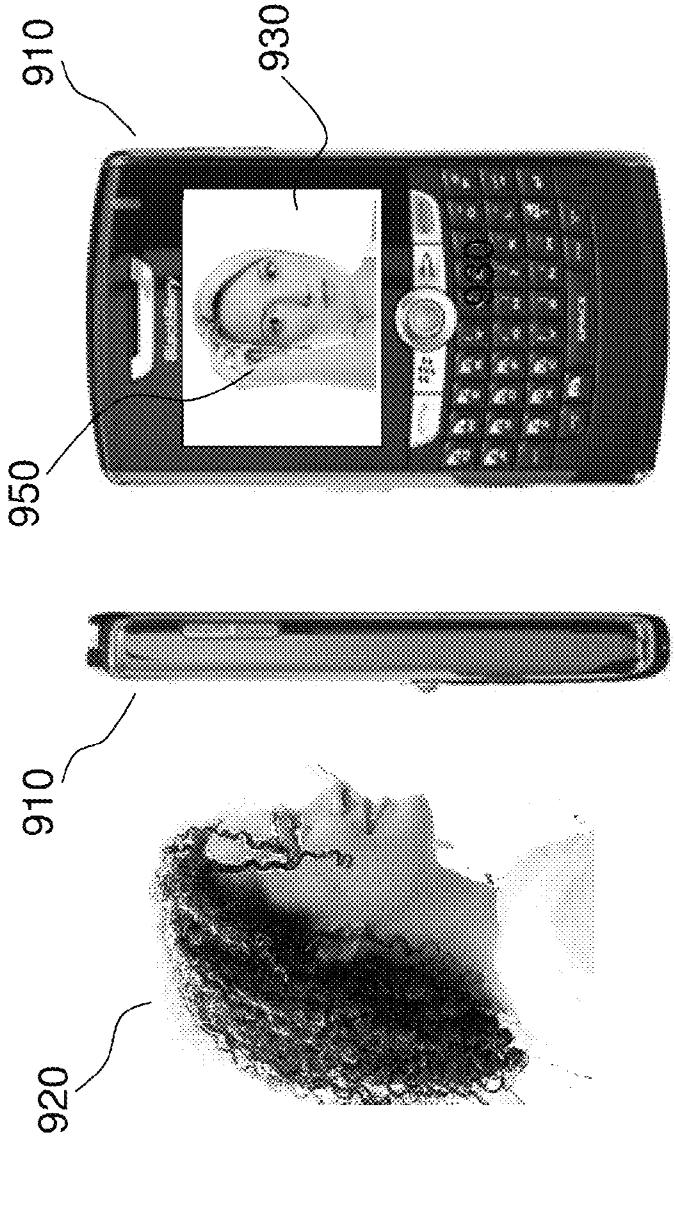


Figure 9A

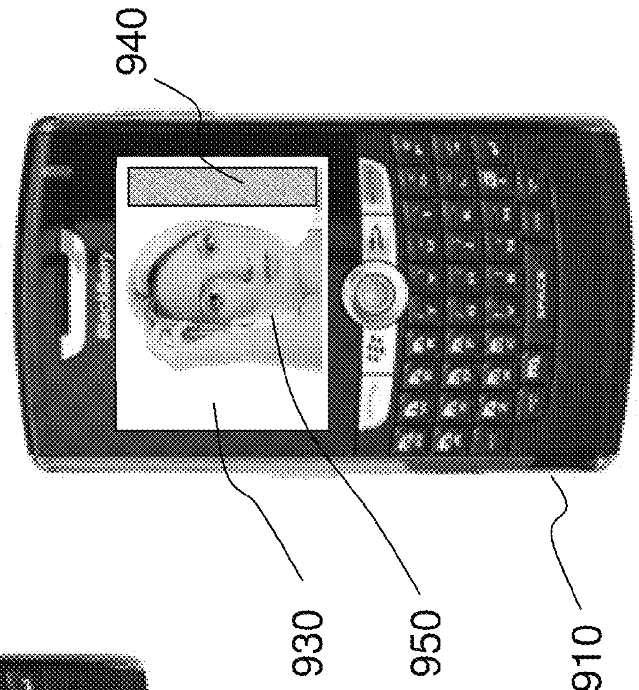


Figure 9B

ENHANCED DISPLAY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority to U.S. Provisional Patent Application Ser. No. 61/244,912 filed Sep. 23, 2009 entitled "Enhanced Display."

FIELD OF THE INVENTION

This invention relates to display devices and more specifically to providing increased confidentiality of information display and functionality of the display device.

BACKGROUND

The Technology, Media and Telecommunications (TMT) business has grown in the past 10 years with the widespread deployment of wireless devices, personal computers, Internet, and broadband networks to represent a value chain of over $3 trillion worldwide, including content providers, advertisers, telecommunications companies and electronics suppliers (White Paper Wireless Social Networking from iSuppli, July 2008). In the next decade wireless social networking products, applications, components, and advertising will generate more than $2.5 trillion in revenue by 2020, according to iSuppli (Press Release, Jun. 4, 2008 http://www.isuppli.com/NewsDetail.aspx?ID=12930).

During the next decade it is anticipated that mobile devices, such as cellular telephones, smart phones, personal digital assistants (PDA), will become the primary channel for viewing content from or accessing the Internet (World Wide Web) for consumers and that many applications such as social networking, email, and financial transactions will have moved largely into the wireless realm providing the degree and type of ubiquitous connection that consumers demand. At the same time it is anticipated that this evolution with be accompanied by the creation of a new generation of applications that will greatly expand the appeal and utility of these devices.

Today there are essentially three levels of users, these being immediate family and close friends, extended friends, and shared interest groups. Today users interact sporadically, but intensely, with extended friends through games, avatars, and general updates and information. Users with common interests communicate in ways that extend into business. The popularity of social networking in business, for trading, online collaboration, and virtual meetings, is also likely to spur advancement of mobile devices equipped for content viewing and sharing and accordingly spur the dominance of mobile devices for other applications including finance, electronic mail, messaging, music etc.

Accordingly, as users move to such wireless devices as their primary means of communicating, accessing content, and using applications in the next decade, the technological innovations will also have to appear within the semiconductor and display industries globally. Increasingly displays will emerge as the most valuable portion of the mobile-device value chain, with makers of portable wireless devices stressing differentiation via superior display technology rather than features which have been important to date including battery lifetime, weight, size, full keyword, etc.

Within a large number of applications on wireless devices, where the user is generally outside their residence, office or other space that is essentially personal to them, there are requirements for enhanced security of information. This information may be that provided and displayed to the user and may include for example a message from a family member, friend, business associate, financial institution, or alternatively be an image, flash movie or other visual media. Similarly this data may that being provided/entered by the user and may include for example a message to a family member, friend, business associate, or financial institution, a user name associated with a web based service provider, a password associated with a web based service provider, a password for accessing the currently locked mobile device etc.

Historically the developments relating to the security of information exchanged between two users be they individuals, businesses, web services, etc have been focused to the actual transmission process/processes and ensuring that attacks such a "relay attacks", "birthday attack" or "man-in-the-middle attacks". As such activities therein have focused to cryptographic techniques such that terms including symmetric key, asymmetric key, public key, and private key have become in many instances part of the knowledge or ordinary people as security breaches occur with financial institutions etc. Accordingly cryptographic protocolssuch as Transport Layer Security (TLS) and its predecessor, Secure Sockets Layer (SSL) provide security and data integrity for communications over networks such as the Internet. TLS and SSL encrypt the segments of network connections at the Transport Layer end-to-end. Several versions of the protocols are in wide-spread use in applications like web browsing, electronic mail, Internet faxing, instant messaging and voice-over-IP (VoIP).

Beyond such communication applications security requirements exist for the fledgling electronic commerce (e-commerce) applications being deployed with mobile devices. In the period April-June 2009 (Q2 2009) e-commerce was $32.4 billion but still only represented approximately 3.6% of the overall retail sales market in Q2 2009 of $900 billion (U.S. Census Bureau "2nd Quarter 2009 Retail E-Commerce Sales Report" released on Aug. 17, 2009). Accordingly e-commerce extends security requirements such as identification and authentication, authorization and access control, data integrity, confidentiality, non-repudiation, trust, and regulation exploiting technologies such as Internet security, firewalls, cryptography, digital signatures, secure email, public key infrastructure, intellectual property protection and watermarking, Java security, database security, secure electronic payments such as secure electronic transaction (SET), digital cash, digital cheques, and smart card technology.

However, despite the significant investments by Governments, financial institutions, and other enterprises in resources, ingenuity, infrastructure etc to protect individuals and enterprises there still exists the ability for a breach of security to occur as the user credentials in accessing their account, a particular transaction or their electronic mobile device for example can be obtained by a malevolent individual acting alone or in concert with others. For example, the malevolent individual may film the keypad entries made by a series of users when accessing their financial institutions via an automatic teller machine, they may establish a dummy terminal within a retail establishment to capture user information, or they may simply be next to an individual and be looking sideways towards the user when they enter their username or password for example to access their financial institution from their mobile device whilst sitting on a bus, train, or other form of mass transportation, be sitting in a coffee shop, restaurant, library or other public space or be standing in the street. Equally a malevolent individual or individual snooping may view any information displayed on the users LCD display of their mobile device which can be content that is personal, business, financial, adult etc.

Typically the displays on their mobile devices, be they laptops, palmtops, cellular telephones, personal digital assistants (PDAs) are liquid crystal displays (LCDs). Unfortunately for users entering access information such as usernames, passwords etc into their mobile devices the historical drive within the TMT business has been to seek to increase the viewing angle of LCD displays for their use within televisions, computers, mobile devices etc. Accordingly the malevolent user with time has been granted better visibility of the information displayed, entered and generated upon a user's mobile device.

Accordingly it would be beneficial to limit the external viewing angle of LCD displays on mobile devices. However, whilst appearing a high volume market LCD displays for mobile devices leverage manufacturing scale by combining a common design and manufacturing platform with the LCD displays for televisions or computers. For example, a single 18" LCD display for a laptop computer is the equivalent of 22 2.5" LCD displays for an Apple iPhone® or Blackberry Curve®, and a single 42" LCD television by contrast is the equivalent of 120 2.5" LCD displays for typical mobile devices. Hence, selling 2 million televisions requires the same overall LCD manufacturing capacity as does 240 million mobile device.

As such in order to maintain this manufacturing leverage it would be beneficial for the limitation of viewing angle for mobile devices to be an element that is either added to the LCD display or is a modification to an element within the design that can be introduced without changing the overall manufacturing process flow.

It is, therefore, desirable to provide a means of limiting the viewing angle of the LCD display for a mobile device in order to reduce the potential for information displayed on the LCD display being viewed by other individuals in the immediate vicinity of the mobile device user.

SUMMARY

It is an object of the present invention to obviate or mitigate at least one disadvantage of the prior art.

In accordance with an embodiment of the invention there is provided a method comprising providing a display comprising a display surface for presenting visual information, and providing an optical element for use in conjunction with the display so as to reduce a predetermined characteristic of the display.

In accordance with another embodiment of the invention there is provided a method comprising providing a device comprising at least a display wherein the display comprises a display surface for presenting visual information and a pixel of a plurality of pixels of controllable transparency, providing an optical element for use in conjunction with the display so as to reduce a predetermined characteristic of the display, and adjusting the transparency of the pixel to a predetermined setting in dependence upon at least a user of the display selecting at least one of a predetermined application on the device and a predetermined button on the device.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

FIGS. **1**A through **1**F depict the operating principles for LCD elements within LCD displays;

FIG. **2** is a cross-section of a transflective LCD display;

FIG. **3**A depicts how viewing angle is determined for an LCD display;

FIG. **3**B shows how large the viewing angle for an LCD within a current commercial mobile device;

FIG. **4** depicts propagation of light within an LCD display according to the prior art;

FIG. **5**A depicts propagation of light within an LCD display according to an embodiment of the invention;

FIG. **5**B depicts an embodiment of the invention;

FIG. **6** depicts a range of display overlays according to embodiments of the invention;

FIG. **7** depicts propagation of light within an LCD display according to an embodiment of the invention;

FIG. **8** depicts propagation of light within an LCD display according to an embodiment of the invention;

FIG. **9**A depicts an application exploiting the restricted viewing angle of the LCD display according to an embodiment of the invention to provide a mirror; and

FIG. **9**B depicts an embodiment of the application wherein a programmable light emitting element is employed to provide a mirror application for low lighting levels.

DETAILED DESCRIPTION

The present invention is directed to providing increased confidentiality in the displaying of information to a user of a device comprising a display.

Reference may be made below to specific elements, numbered in accordance with the attached figures. The discussion below should be taken to be exemplary in nature, and not as limiting of the scope of the present invention. The scope of the present invention is defined in the claims, and should not be considered as limited by the implementation details described below, which as one skilled in the art will appreciate, can be modified by replacing elements with equivalent functional elements.

Referring to FIG. **1**A there is depicted an exploded schematic diagram of a reflective LCD display **100** according to the prior art. Accordingly there is shown a first polarizer **101**, electrode sheet **102** which comprises a glass carrier with transparent indium tin oxide (ITO) electrodes, liquid crystal layer **103**, and ground plane **104** which comprises a second glass substrate with a continuous ITO electrode. Behind this is then the second polarizer **105** and mirror **106**. Accordingly in use an applied electric field between an electrode on the electrode sheet **102** and ground plane **104** defines the amount of rotation induced by the liquid crystal **103** onto the polarized light passed by the first polarizer **101**, and therein how much light is passed by the second polarizer **105** and therein reflected from the mirror **106**.

Similarly referring to FIG. **1**B there is shown an exploded schematic diagram of a transmissive LCD display **110** according to the prior art. Accordingly there is shown a first polarizer **101**, electrode sheet **102** which comprises a glass carrier with transparent indium tin oxide (ITO) electrodes, liquid crystal layer **103**, and ground plane **104** which comprises a second glass substrate with a continuous ITO electrode. Behind this is then the second polarizer **105** and light source **106**. Accordingly in use an applied electric field between an electrode on the electrode sheet **102** and ground plane **104** defines the amount of rotation induced by the liquid crystal **103** onto the polarized light passed by the second polarizer **115** from the light source **116**, and therein how much light is passed by the first polarizer **111** and therein to the user.

Referring to FIG. **1**C there is shown an exploded schematic diagram of a colour pixel of an LCD display **120** according to the prior art. Accordingly there is shown a first polarizer **122**, electrode sheet **123** which comprises a glass carrier with transparent indium tin oxide (ITO) electrodes, liquid crystal layer **124**, and ground plane **125** which comprises a second glass substrate with a continuous ITO electrode. Behind this is then the second polarizer **126**, such that if a light source is provided behind the second polarizer a transmissive LCD is provided and if a mirror is provided then a reflected LCD is implemented. In front of the first polarizer **122** is a color filter **121**. In this manner the LCD be it reflective or transmissive provides electrical control of the intensity of the particular part of the LCD display (not shown for clarity) which has the color filter **121** in front of it.

As a result utilizing three pixels spatially grouped with red, green and blue filters the group acts to provide any color to the human eye. An example of such a color LCD display is shown in first color display **130** within FIG. **1**D. As shown the first color display **130** comprises red color filters **131**, blue color filters **132** and red color filters **133** which repeat across the first color display **130** in a grid pattern. First color display **130** being for example used within the One Laptop Per Child (OLPC) XO-1 computer. Now referring to FIG. **1**E there is shown a second color display **140** such as a thin film transistor (TFT) LCD employed within many computers, laptops and televisions. Again the second color display **140** comprises an array of pixels which are then covered by red filters **141**, blue filters **142** and green filters **143**. Further shown in FIG. **1**F is an alternative design for an LCD, unexploited to date, which depicts a third color display **150** which comprises a repeating group **155** of the three color filters in a hexagonal close packed design.

Now referring to FIG. **2** there is shown a cross-section of a cross-section of a transflective LCD display **200**. Accordingly there is shown a front cover **250** which is disposed over a first polarizer **240** and an electrode substrate **290** which has disposed the array of control electrodes **280**. Disposed above the control electrodes **280** are the color filters, shown as red filter **262**, green filter **264**, and blue filter **266**. Below the electrode substrate **290** is the liquid crystal layer **230**. Beneath this are half-mirror **220**, second polarizer **295**, and backlight **210**. In operation light entering the transflective LCD display **200**, such as first optical signal **276**, passes through an optical filter, such as green filter **264**, the electrode substrate **290**, and control electrode **280** before passing through the liquid crystal and being reflected by half-mirror **220**

After being reflected from the half-mirror **220** this reflected optical signal **278** passes back through the layers of the transflective LCD display **200** and to the viewer. Optical signals generated within the backlight **210** such as second optical signal **272** passes through the second polarizer **295**, half-mirror **220** before propagating through the liquid crystal, control electrode **280**, electrode substrate **290**, first polarizer **240**, and an optical filter, such as red filter **262** or blue filter **266** before propagating to the viewer. As such the transflective LCD display **200** can operate with both ambient light and light emitted from the backlight **210**. As such a transflective LCD display **200** operates over a wider range of lighting than a conventional reflective design such as described supra in FIG. **1**A and with reduced power consumption when compared to a standard transmissive design such as described supra in FIG. **1**B.

Referring to FIG. **3**A there is depicted a mobile device **310** which includes an LCD display **320** such as a transflective LCD as described supra in respect of FIG. **2**. The display **320** is characterized by many parameters that users of the mobile device will be familiar with such as its resolution or number of pixels etc. However, another parameter of the LCD display **320** not generally known but evident to the user during their use of the mobile device **310** is the viewing angle which is depicted by angles Ω_1 **330** and Ω_2 **340** which represent the viewing angle away from the perpendicular. Typically the viewing angle is stated as the angle at which the contrast ratio for the viewer drops to 10:1. Today typical viewing angles for Ω_1 **330** and Ω_2 **340** are 70° to 80° each. Whilst this contrast ratio may mean that the colors may look a little different the information on the display is still visible to a malevolent viewer, especially where the content for example is simple text as typically the case with security logins etc.

Recently companies such as Sharp have reported viewing angles as high as 88°. Such a wide viewing angle having been previously viewed as a marketing asset for mobile device manufacturers. Referring to FIG. **3**B there is shown such an LCD display being shown as viewed at the perpendicular in central image **350**, and at high non-perpendicular viewing angles from above the perpendicular in upper image **352**, from below the perpendicular in lower image **358**, to the left of the perpendicular in left image **354**, and to the right of the perpendicular in right image **356**. As is evident in these images today LCD displays provide excellent off-perpendicular viewing. However, for the average user sitting holding their mobile device the question is just how much benefit are such wide viewing angles when they compromise the security and confidentiality of information displayed upon them.

Referring to FIG. **4** there is depicted a schematic **400** of the propagation of light within an LCD display according to the prior art. As shown the schematic **400** depicts a transflective design comprising first to fourth colour groups **420**, **430**, **440** and **450** which comprise red, green and blue filter elements associated with electrodes on the upper transparent ITO film. Now consider light entering the LCD display from a point away from the user. First light **460**A propagates and enters the fourth color group **450**, reflects of the half-mirror **410** wherein it is reflected back as second light **460**B through the fourth color group **450**. Similarly third light **470**A propagates through the fourth color group **450**, reflects of the half-mirror **410** as fourth light **470**B and exits the LCD display through the third color group **440**. Similarly fifth and sixth lights **480**A and **490**A enter the LCD display via the fourth and third color groups **450** and **440** respectively and are reflected from the half-mirror **410** as seventh and eighth lights **480**B and **490**B respectively which then exit the LCD display through the second and first color groups **430** and **420** respectively.

If the transflective display presented within FIG. **4** was being employed in a high ambient light environment then the display would be slightly reduced in contrast with light from the source providing the first, third, fifth and seventh lights **460**A, **470**A, **480**S and **490**A respectively being returned to the viewer via all of the four color groups **420** to **450**. In each instance the light along a path is the combination of the liquid crystal polarization rotation of multiple color groups rather than an intended single color group. Whilst perhaps not noticeable to a user under normal operating conditions the multiple paths that light from a single point off axis may take within the LCD and exit to the viewer becomes evident when considering some potential applications where either the distribution of displayed light is sensitive, such as displaying very high contrast information, or wherein the image presented to the user is based upon the ambient environment or even wherein the backlight is a multiple function device. Examples of applications for current mobile devices for example include providing a mirror to the user. Examples of multi-function devices forming part of the LCD display **400** include employing solid state semiconductor light emitting diodes (LEDs) which under forward bias act as emitters but under reverse bias act as detectors. Accordingly one can consider applications wherein the user may simultaneously view information and record audio-visual content.

Referring to FIG. **5**A there is depicted a schematic diagram of the propagation of light within an LCD display **500** according to an embodiment of the invention. As shown the LCD display **500** is a transflective design with a light element **515** and half-mirror **510**. Disposed in front of the cover **510**D is optical element **510**C, and shown within the LCD display **500** are first through fourth sub-structures **520** through **550** which comprise colour filters (red, green, blue) on the upper side of electrode substrate **510**E and electrode contacts on the lower side of electrode substrate **510**E.

As shown on the left hand side of the schematic four light paths, first through fourth paths **560**A through **590**A respectively which orientate from in front of the cover **510**D. Each of the first through fourth paths **560**A through **590**A respectively passes through the optical element **510**C and becomes nearly perpendicular to the LCD display **500** as shown by fifth through eighth paths **560**B through **590**B respectively. Accordingly upon reflecting from the half-mirror **510** the fifth through eighth paths **560**B through **590**B respectively are redirected by the optical element **510**C along first through fourth paths **560**A through **590**A. Similarly ninth to twelfth paths **560**C through **590**C respectively propagate through the optical element **510**C becoming thirteenth through sixteenth paths **560**D through **580**D respectively. In a similar manner reflection from the half-mirror **510** results in the thirteenth through sixteenth paths **560**D through **590**D respectively are redirected by the optical element **510**C along ninth through twelfth paths **560**C through **590**C.

Referring to FIG. **5**B there is depicted another LCD display **5000**A according to an embodiment of the invention wherein a first optical element **5200** is inserted between a light element **5300** and the half-mirror **5100**. The optical element **5200** acts to provide a degree of collimation to light emitted from the light element **5300** as shown by first and second light path groups **5400**B and **5400**D respectively. These partially collimated or collimated light paths are then acted upon by a second optical element **5500** in front of the cover **5600** of the LCD display **5000** to provide focusing sets of light path groups **5400**A and **5400**C for each of the light path groups **5400**B and **5400**D respectively.

Further depicted in FIG. **5**C is an LCD display **5000**B according to an embodiment of the invention wherein an optical element **5600** is inserted above the half-mirror **5700** and light element **5800**.

It would be evident to one skilled in the art that the focusing applied by the second optical element does not have to be of high optical power as the second optical element is intended to reduce the effective viewing angle of the LCD display **5000**.

Now referring to FIG. **6** there are shown a plurality of overlay, first through fourth overlays **610** to **640** respectively, which may be provided for an optical element according to embodiments of the invention, such as second optical element **5500** of FIG. **5**B and optical element **510**C of FIG. **5**A. As depicted first overlay **610** comprises a repeating pattern of optical elements **615**, which may for example be configured to be repeated with a pitch that matches the pitch of the three color filters within the LCD display or group of pixels within a monochrome display. As such the optical element **615** may be circularly symmetric when exploited with an LCD display such as third color display **150** in FIG. **1**F where a circular structure of the three filters is employed. Alternatively the optical element **615** may be asymmetric such as to operate with a single group or multiple groups of color filters within first color display **130** in FIG. **1**D and second color display **140** in FIG. **1**E.

Similarly second overlay **620** comprises a repeating array of optical structures **620**, in this case where each optical structure is based upon a Fresnel lens such that each three pixel color group or predetermined subset of pixels within the LCD display may be coupled to a single emitting element in the backlight rather than a distributed backlight. In this manner second overlay **620** allows for a backlight design based upon a semiconductor substrate of vertical light emitting diodes. Third overlay **630** comprises a central optical element **635** in conjunction with two peripheral optical elements **634** and **638**. In this manner the design for the optical elements varies according to a relationship that is based upon separation of the pixels within the LCD display from a nominal central point or region. Also shown is fourth overlay **640** which comprises a repeating sequence of identical optical elements **644** which are dimensioned either to each pixel within the LCD display irrespective of color, or to a color group or predetermined subset of the display pixels.

It would be evident to one skilled in the art that the first to fourth overlays **610** through **640** respectively may also be employed as optical elements within the LCD display such as presented supra in respect of FIGS. **5**B and **5**C. Further it would apparent to one of skill that the LCD display may combine multiple optical elements, including for example an optical element between the backlight and half-mirror or backlight and lower polarizer, and another in front of the cover plate. It would also be apparent that such optical elements may be disposed at other positions within the LCD display to achieve the same results.

It would also be evident to one of skill in the art that the implementation of the optical elements may vary according to their position within the overall display as well as whether they are integrated to the overall LCD manufacturing sequence. For example a modified Fresnel type lens or simple lens such as displayed by second and fourth overlays **620** and **640** respectively of FIG. **6** may be implemented within a semiconductor based backlight by forming the structure within a transparent passivation layer to the backlight such as silicon dioxide, silicon nitride, spin-on glasses (SOG) and polymers. Similarly these structures and others described in respect of the different embodiments of the invention may be manufactured with silica substrates that may be employed in forming the cover plate of the LCD display or electrode substrates such as for example cover **250**, electrode substrate **290**, and half-mirror **220** of FIG. **2** supra.

Alternatively the optical element may be disposed above the LCD display such as shown in FIG. **5** wherein the optical element may again be formed in substrate materials such as glass or silica but may also be formed by molding or stamping polymeric materials. In one embodiment it is possible to consider that the optical element is formed within a clear window of a protective case for the mobile device comprising the LCD display. In this manner the restriction to viewing angle may be sold as an after-market option for existing mobile devices.

Now referring to FIG. **7** there is depicted an exemplary schematic **700** of the propagation of light with respect to an LCD display **710** according to an embodiment of the invention with an optical element **720**. As shown LCD display **710** comprises a backlight (not identified separately for clarity) and is a transflective design allowing reduced power consumption operation under high ambient lighting conditions. As such considering the low light level scenario the backlight is operational and hence optical signals **750** are coupled from the backlight through the liquid crystal, polarizers, and filters to generate the display as determined by the mobile device in response to the user's actions. These optical signals **750** then impinge upon the optical element **720** wherein they are diffracted towards the user as user signals **731** through **736** respectively. In this manner the image of the display is not viewable to a malevolent user (not shown for clarity) who is disposed away from the perpendicular axis of the LCD display **710**.

Now considering the case for high ambient light levels surrounding the user then the backlight would be turned off or considerably reduced in emission level. Now user signals **731** through **736** represent optical signals within the ambient environment that are associated with the perpendicular axis of the LCD display **710** and therein under normal operating conditions an imaginary line between the LCD display and the user's face. The user signals **731** through **736** upon impinging the optical element **720** are refracted and become display signals **760** which propagate through the LCD display **710** and are reflected as optical signals **750**. These reflected signals then propagate back to the user along the same light paths as user signals **731** through **736**. Ambient signals **742** and **746** respectively representing signals from the ambient environment at high angles of incidence to the LCD display **710** and optical element **720** are reflected back at high incidence as reflected signals **744** and **748** respectively. Accordingly a malevolent user disposed away to the side of the LCD display **710** and the user of the mobile device to which LCD display **710** comprises part will see a reflected image of the environment to the other side of the user and does not receive optical signals from the LCD display **710**.

It would be evident that imperfections occur in real world devices and hence the increased reflectance of the LCD display **710** to signals with high incidence acts to decrease any contrast ratio for information originating from the LCD display **710** thereby making the actions of the malevolent user even more difficult.

Referring to FIG. **8** there is depicted an exemplary schematic **800** of the propagation of light with respect to an LCD display **810** according to an embodiment of the invention with an optical element **820**. As shown LCD display **810** comprises a backlight (not identified separately for clarity) and is a transflective design allowing reduced power consumption operation under high ambient lighting conditions. As such considering the low light level scenario the backlight is operational and hence optical signals **850** are coupled from the backlight through the liquid crystal, polarizers, and filters to generate the display as determined by the mobile device in response to the users' actions. These optical signals **850** then impinge upon the optical element **820** wherein they are diffracted towards the user as user signals **831** through **836** respectively. In this manner the image of the display is not viewable to a malevolent user (not shown for clarity) who is disposed away from the perpendicular axis of the LCD display **810**.

Now considering the case for high ambient light levels surrounding the user then the backlight would be turned off or considerably reduced in emission level. Now user signals **831** through **836** represent optical signals within the ambient environment that are associated with the perpendicular axis of the LCD display **810** and therein under normal operating conditions an imaginary line between the LCD display and the user's face. The user signals **831** through **836** upon impinging the optical element **820** are refracted and become display signals **860** which propagate through the LCD display **810** and are reflected as optical signals **850**. These reflected signals then propagate back to the user along the same light paths as user signals **831** through **836**. Ambient signals **842** and **846** respectively representing signals from the ambient environment at high angles of incidence to the LCD display **810** and optical element **820** are reflected back at high incidence as reflected signals **844** and **848** respectively. Accordingly a malevolent user disposed away to the side of the LCD display **810** and the user of the mobile device to which LCD display **810** comprises part will see a reflected image of the environment to the other side of the user and does not receive optical signals from the LCD display **810**.

Now referring to FIG. **9**A there is depicted an application exploiting the restricted viewing angle of the LCD display according to an embodiment of the invention to provide a mirror to the user. As shown a user **920** is facing a mobile device **910** which comprises a display **930** according to an embodiment of the invention. Accordingly as described supra in respect of FIGS. **7** and **8** under high ambient light levels then only optical signals originating within a restricted angle range of the user will propagate to the display **930** and be reflected back to the user. Now if the control electrodes within the display **930** are all set to allow maximum transmittance then the light returned to the user will be that originating around them and hence they will see their face **950** on the display **930**.

Referring to FIG. **9**B another embodiment of the invention is depicted wherein the display **930** contains a backlight which is programmable in respect to the predetermined portion of the display that is turned on. As such a light **940** is turned on under low ambient lighting conditions which by again setting all electrodes within that region to maximum transmittance is essentially white light it will act as illumination for the user, not shown for clarity, such that the light reflecting from their face to the display **930** will be reflected again to them such that they see their image **950** even under low lighting levels.

The above-described embodiments of the present invention are intended to be examples only. Alterations, modifications and variations may be effected to the particular embodiments by those of skill in the art without departing from the scope of the invention, which is defined solely by the claims appended hereto.

What is claimed is:

1. A method comprising:

a transflective liquid crystal display (TLCD) comprising a display surface for presenting visual information; and

a passive transparent optical element substantially parallel to the display surface of the TLCD on the user side of the TLCD for use in conjunction with the TLCD so as to reduce at least one of visibility of the display and a contrast ratio of visual information displayed on the TLCD unless viewing the display approximately perpendicular to the display surface of the TLCD, wherein the transparent optical element is entirely optically transparent and does not contain light absorbing regions or light diffusing regions.

2. A method according to claim **1** wherein, said optical element is at least one mounted within another device also comprising the TLCD and is disposed approximately parallel to the display surface.

3. A method according to claim **1** wherein, the optical element comprises a predetermined portion the TLCD.

4. A method according to claim **1** wherein, the optical element is disposed between at least two elements of the TLCD, the elements of the TLCD selected from the group comprising a cover, a partially reflecting element, a first polarizer, a second polarizer, an electrode structure within the TLCD controlling the presented visual information, and a color filter.

5. A method according to claim **1** wherein, the optical element is formed by a fabrication process wherein a predetermined step of the process comprises a process selected from the group comprising stamping, molding, etching, and depositing.

6. A device comprising:

a transflective LCD display (TLCD) comprising a display surface for presenting visual information; and

a passive transparent optical element substantially parallel to the display surface of the TLCD on the user side of the TLCD for use in conjunction with the display so as to reduce at least one of visibility of the display and a contrast ratio of visual information displayed on the TLCD unless viewing the display approximately perpendicular to the display surface of the TLCD, wherein the transparent optical element is entirely optically transparent and does not contain light absorbing regions or light diffusing regions.

7. A device according to claim **6** wherein, the optical element comprises a predetermined portion the TLCD.

8. A device according to claim **6** wherein, the optical element is disposed between at least two elements of the TLCD, the elements of the display selected from the group comprising a cover, a partially reflecting element, a first polarizer, a second polarizer, an electrode structure within the display controlling the presented visual information, and a color filter.

9. A device according to claim **6** wherein, the optical element is formed by a fabrication process wherein a predetermined step of the process comprises a process selected from the group comprising stamping, molding, etching, and depositing.

10. A method comprising:

providing a device comprising at least a transflective LCD display (TLCD) wherein the TLCD comprises a display surface for presenting visual information and a pixel of a plurality of pixels of controllable transparency;

providing a transparent passive optical element substantially parallel to the display surface of the TLCD on the user side of the TLCD for use in conjunction with the TLCD so as to reduce at least one of visibility of the display and a contrast ratio of visual information displayed on the TLCD unless viewing the display approximately perpendicular to the display surface of the TLCD, wherein the transparent optical element is entirely optically transparent and does not contain light absorbing regions or light diffusing regions; and

adjusting the transparency of the pixel to a predetermined setting in dependence upon at least a user of the TLCD selecting at least one of a predetermined application on the device and a predetermined button on the device.

11. A method according to claim **10** wherein, adjusting the transparency of the pixel of the plurality of pixels in conjunction with the optical element provides to the user a predetermined portion of a reflection of the user and their immediate surroundings.

12. A method according to claim **10** further comprising;

providing a backlight as part of the device; and

operating a predetermined portion of the backlight in response to the user selecting at least one of the predetermined application on the device and the predetermined button on the device.

13. The method according to claim **1**, wherein the reduction within the predetermined characteristic of the display to a user unless viewing the display approximately perpendicular to the display surface of the TLCD occurs as the user's viewing angle away from the perpendicular increases either to the left or the right of the perpendicular to the display surface.

14. The method according to claim **6**, wherein the reduction within the predetermined characteristic of the display to a user unless viewing the display approximately perpendicular to the display surface of the TLCD occurs as the user's viewing angle away from the perpendicular increases either to the left or the right of the perpendicular to the display surface.

15. The method according to claim **10**, wherein the reduction within the predetermined characteristic of the display to a user unless viewing the display approximately perpendicular to the display surface of the TLCD occurs as the user's viewing angle away from the perpendicular increases either to the left or the right of the perpendicular to the display surface.

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